ARIZONA DEPARTMENT OF TRANSPORTATION

SOIL EROSION AND DUST CONTROL ON ARIZONA HIGHWAYS

Part IV Final Report Field Testing Program

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16. Abstract

Several chemical stabilizers were selected for use in a large scale field application, based on a laboratory testing program. Spray-on application of chemicals to control dust and wind erosion on untrafficable areas were made using eleven chemicals. Five chemicals were used on an unpaved road using a spray-on application to control erosion and dust behind traffic. Three chemicals were also used on the unpaved road using a mixed-in application. Methods of field application are given. Details of monitoring techniques including HiVol dust collection, dust fall collection in cups, and extraction tests are discussed. Results indicate availability of several chemicals that proved successful in controlling dust on untrafficable areas. Only two chemical treatments proved successful to control dust on unpaved roads.

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SOIL EROSION AND DUST CONTROL ON ARIZONA HIGHWAYS

FINAL REPORT - FIELD TESTING PROGRAM

by

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Submitted to

The Arizona Department of Transportation
Highways Division
Phoenix, Arizona 85007

for

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ABSTRACT

Several chemical stabilizers were selected for use in a large scale field application, based on a laboratory testing program. Spray-on application of chemicals to control dust and wind erosion on untrafficable areas were made using eleven chemicals. Five chemicals were used on an unpaved road using a spray-on application to control erosion and dust behind traffic. Three chemicals were also used on the unpaved road using a mixed-in application. Methods of field application are given. Details of monitoring techniques including Hi-Vol dust collection, dust fall collection in cups, and extraction tests are discussed. Results indicate availability of several chemicals that proved successful in controlling dust on untrafficable areas. Only two chemical treatments proved successful to provide long-term dust control behind traffic on unpaved roads.

KEY WORDS: Chemical Stabilization, Soil Stabilization, Erosion Control, Dust Control, Wind Erosion, Traffic Erosion, Dust Collection, Field Applications.

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PROJECT SUMMARY

Statement of the Problem

One problem associated with the potential of the arid and semi-arid climate soils to erode is the movement of cohesionless sandy soils due to wind erosion and the development of sand storms and high levels of dust particulates. These dust storms have been the cause of numerous chain car accidents on Arizona highways due to the severe reduction in visibility during such storms.

In addition, the unpaved "gravel" secondary roads have been a continuous item on the maintenance budget because of the need for periodic grading and replacement of material lost through erosion due to traffic. Experience and road studies indicate that annual losses of road material can reach about 200 cubic yards per mile (95 m^3/Km) for unpaved roads. In addition to these gravel losses, the loss of air-borne silt and clay size particulates was estimated to the order of 5 to 50 grams per vehicular mile. With a traffic volume of 250 vehicles per day the dust pollution may amount to 0.5 to 5 tons of air-borne particulates per mile (0.28 to 2.8 tons/Km) per year.

As we are becoming increasingly aware, the above mentioned problems have already posed severe safety, health, and public relations problems and are expected to continue unless positive measures for erosion control are developed and implemented.

Objectives of the Study

The specific aims of the study are to search for, determine, and identify those stabilizing agents that are best capable of controlling soil erosion due to wind and traffic forces and providing positive dust control measures. These selected stabilizers shall be economical, easy to apply in the field, and durable to withstand various environmental conditions.

The ultimate objective of this investigation is the development and implementation of low cost stabilization techniques that will provide positive dust control measures and will result in better specifications for the construction of erosion-resistant roads and for the protection and maintenance of existing erodible secondary roads.

Interim Reports Submitted

This project started on December 6, 1972; the currently approved completion date is February 4, 1976. Due to the length of the investigation and the different phases of the work, it had been agreed upon to submit interim final reports covering completed phases of the study. The following interim reports have been submitted and approved by ADOT and FHWA.

1. Interim Final Report - Part I: That interim final report covered the completed comprehensive literature survey of the state-of-the-art pertaining to the basic parameters affecting soil erosion and the most acceptable soil erosion control and prevention techniques. A detailed review of previous work done on the use of chemical stabilizers for the control of wind

erosion, water-rain erosion, and traffic erosion was included. The report was dated October 1974.

2. Interim Final Report - Part II: That interim final report presented the results of the completed laboratory testing program. The report covered the criteria for selection of chemical stabilizers, the types of soils used in the laboratory, along with the different tests conducted for dust control studies and traffic erosion control studies. The results of the laboratory studies were also presented, evaluated, and discussed. The report was dated October 1974.

3. Progress Report - Field Testing Program: Based on the results of the laboratory studies, several chemical stabilizers were selected for application in a full-scale field evaluation program. The field tests included dust control studies on non-trafficable areas and traffic erosion studies on an unpaved road. The field testing program started in May 1974, and the progress report presented a summary of the available data from field monitoring until September 1974. The report was labeled as Part III and dated October 1974.

Outline of the Final Report on Field Testing Program

This final report, which follows, presents the results of the completed field testing program. The collected field data are presented and analyzed. Overall conclusions and recommendations based on the project's findings are given, along with a summary statement on research implementation. This report is dated February 1976 and it concludes the project.

SOIL EROSION AND DUST CONTROL ON ARIZONA HIGHWAYS

PART IV

FINAL REPORT - FIELD TESTING PROGRAM

CHAPTER 1

INTRODUCTION

This report presents the results of the completed field testing program. The chemicals used in the field applications were selected at the conclusion, and based on the results of, the laboratory testing phase of the project. The field testing program included a spray-on application of chemicals on untrafficable areas which represents a wind erosion control or a dust control measure only. Road tests for spray-on and mixed-in applications of chemicals were also conducted for traffic erosion control and control of dust due to traffic.

It is pointed out that this report constitutes Part IV in a series of reports submitted covering the results of this project. Part I (Sultan, 1974a) included the state-of-the-art literature review. Part II (Sultan, 1974b) included the results of the laboratory testing phase of the study. Part III (Sultan, 1974c) presented a progress report summarizing the preliminary results of the field study after about 3 months of monitoring the applications. This report, Part IV, presents the detailed results for the completed testing program and is titled as a final report since it completes the project.

SCOPE OF THE FINAL REPORT

In this report a brief summary of the field test activities is given first to provide background for the reader and understanding of the data collected. This summary outlines the chemicals used for each application, the types of field applications, the methods used in applying the chemicals and the various monitoring tests used to evaluate the field performance of the chemical treatments. Most of these items have been previously given in the Progress Report-Part III (Sultan, 1974c) in more detail. The main scope of this report is to present the results of the completed field testing program. The collected data are presented and analysed. The overall conclusions and recommendations based on the project's findings are given. In addition, a summary statement on research implementation is also given.

CHAPTER 2

FIELD APPLICATIONS - DUST CONTROL SITES

The restriction of untrafficability imposed on this application necessitated that the treated areas be protected from pedestrians, drag-racers, pranksters, and animals that would disturb the surface treatment. A site was used at the University of Arizona Agricultural Experiment Station (AES) Farm, in Tucson. Two months after the application of the chemicals at the AES farm site, during which the summer thunderstorms started accompanied with above normal rainfall, weeds started to grow profusely. The growth of weeds obscured the conditions of the sprayed surfaces and affected the dust collection data. Accordingly, another site was sought, prepared, and sprayed with the chemicals along with a weed control agent. This new site was selected adjacent to the ADOT District Maintenance Yard (ADOT Yard), in Tucson.

AES Farm Site

Site Preparation

The northwest corner of the AES farm, at the intersection of Dodge Street and River Road, in Tucson was the location assigned for this site. An area of 120 feet (36.6 m) by 220 feet (67 m) was allocated for use on this project. The site had been previously used for farming and had been disc-harrowed several months prior and was relatively free of weeds. The assigned test area was leveled and smoothed over using a steel drag. The combination of these activities left the top 3 to 6 inches (7.62 to 15.24 cm) reasonably loose. The area was then subdivided into 14 plots of 20 feet by 40 feet (6.1 m by 12.2 m) each, as shown in Figure 1. The physical and mechanical properties of the surface soils encountered at the AES farm site are shown in Table 1.

Chemicals Applied

As pointed out in the Interim Report - Part II, eleven chemicals were decided upon for use in the field application, in addition to the use of water for a control section. Each one of these chemicals is briefly discussed below. For each chemical, the outline includes its major constituents, the dilution ratio, the rate of application and the cost of application per square yard for the chemical only. The number given after the chemical name refers to the number assigned to each chemical during the laboratory testing program.

1. <u>Water (0)</u>: Water was applied on a control section at the rate of 1/2 gsy (2.26 liters/m^2).
2. <u>Aerospray 70 (7)</u>: Its major constituent is a polyvinyl acetate resin. The dilution ratio is 1 to 20 in water, and the application rate is 1/2 gsy (2.26 liters/m^2). The cost of the chemical application is 5.95 cents and 6.50 cents per square yard (7.12 and 7.77 ¢/m^2), F.O.B. Torrence, California and F.O.B. Tucson, Arizona, respectively.
3. <u>Surfaseal (13)</u>: The composition was not given by the manufacturer. The recommended dilution ratio is 1 to 20 in water, and solution applied at 1/3 gsy (1.5 liters/m^2). The cost of this chemical application is 6.3 cents and 6.78 cents per square yard (7.53 and 8.11 ¢/m^2), F.O.B. Daly City, California and

TABLE 1

FIELD SOILS PROPERTIES

Soil Property	Wilmot Road Soil	AES Farm Soil	ADOT Yard Soil
Specific Gravity	2.64	2.60	2.60
Liquid Limit, %	21.0	24.5	29.0
Plasticity Index, %	5.6	4.5	18.2
St. AASHTO, σ_{max}pcf	124.0	-	-
St. AASHTO, W_{opt}%	11.0	-	-
Mod. AASHTO, σ_{max},pcf	131.0	-	-
Mod. AASHTO, W_{opt}%	8.0	-	-
pH value	8.0	7.7	8.3
Soluble Salts, ppm	238.0	1820	987
Nitrates (NO_3), ppm	9.4	1258	18.2
Phosphates (PO_4), ppm	2.7	26.4	8.2
Sulfates (SO_4), ppm	18.0	150	306
Organic Matter, %	0.05	0.79	0.5
Percent Passing, 2 microns	8	15	5.0
Percent Passing #4	99	96	96
Percent Passing #200	28	47	60

1 pcf = 16 Kg/m^3

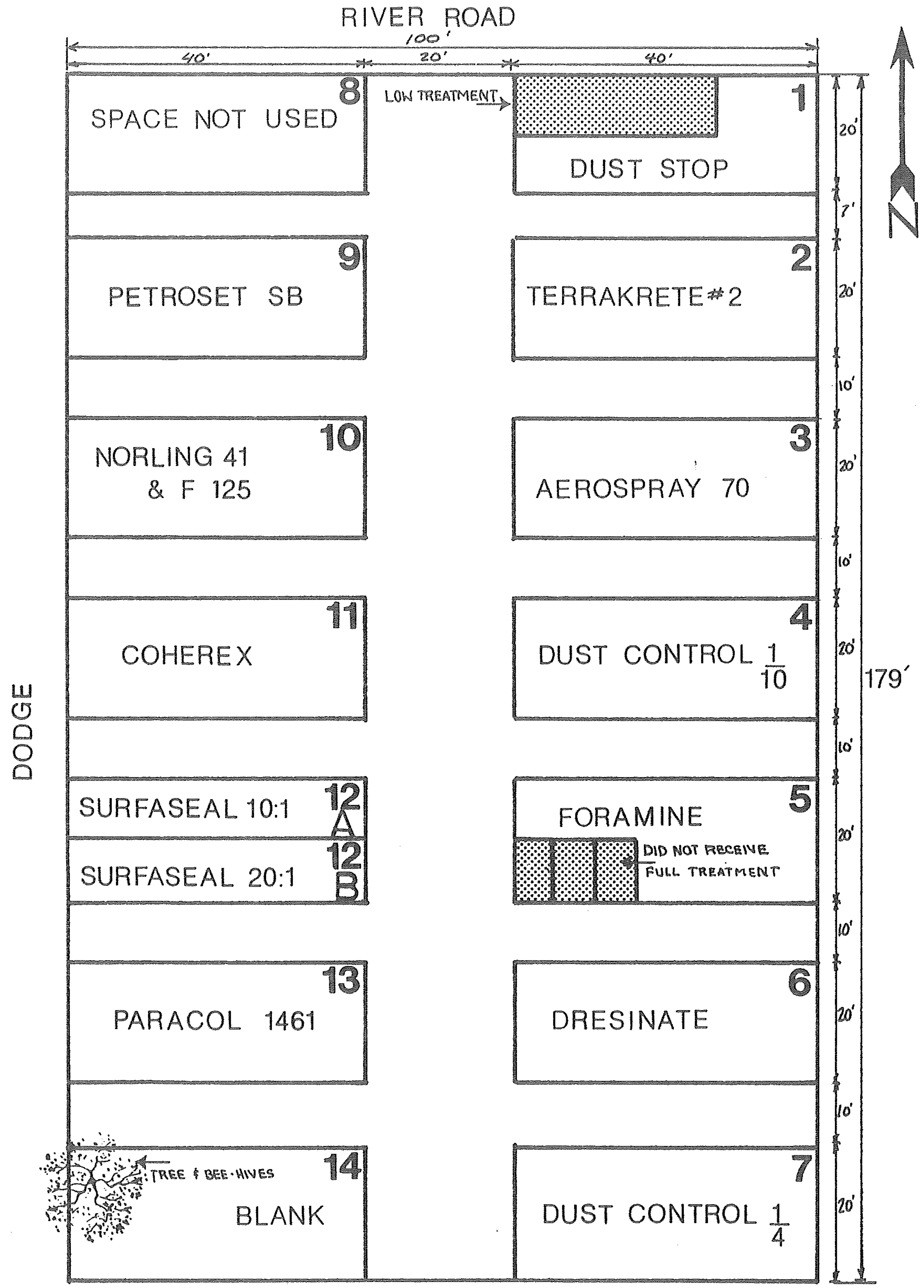


FIGURE 1- LOCATION OF TEST PLOTS, AES FARM SITE

and F.O.B. Tucson, Arizona respectively. At the time of application, the manufacturer was present at the site and requested dividing the allocated plot in two sections. One half was given the recommended application given above, while the other half received the same rate of application, but at a 1 to 10 dilution ratio. The cost of the latter application is 12 cents and 12.94 cents per square yard, (14.35 and 15.47 ¢/m^2) F.O.B. Daly City, California, and F.O.B. Tucson, Arizona respectively.

4. Petroset SB (20): This is a butadiene-styrene rubber and resin tacifier in an oil-water emulsion. The dilution ratio is 1 to 25 in water, and solution applied at 1.0 gsy (4.52 liters/m^2). The cost of this chemical application is 5.8 cents and 6.61 cents per square yard (6.93 and 7.9 ¢/m^2), F.O.B. Borger, Texas and F.O.B. Tucson, Arizona, respectively.
5. Coherex (21): This is an emulsion consisting of 60% semi-liquid natural petroleum resins and 40% wetting solution. The dilution ratio is 1:7 in water, and solution applied at 1.0 gsy (4.5 liters/m^2). The cost of this chemical application is 2.9 cents and 5.8 cents per square yard (3.47 and 6.93 ¢/m^2), F.O.B. Bakersfield, California and F.O.B. Tucson, Arizona respectively.
6. Dresinate DS-60W-80F (25): This is a dispersion of a thermoplastic resin and a viscosity reducer. The dilution ratio is 1 to 9 in water, and solution applied at 1.0 gsy (4.52 liters/m^2). The cost of this application is 3.4 cents and 5.95 cents per square yard (4.07 and 7.12 ¢/m^2), F.O.B. Portland, Oregon, and F.O.B. Tucson, Arizona, respectively.

7. Paracol 1461 (26): This is a wax thermoplastic resin blend. The dilution ratio is 1 to 9 in water, and solution applied at 1.0 gsy (4.52 liters/m^2). The cost of this application is 3.9 cents and 6.52 cents per square yard (4.66 and 7.79 ¢/m^2), F.O.B. Portland, Oregon and F.O.B. Tucson, Arizona, respectively.
8. Terrakrete #2 (27): This is a vinyl acetate acrylic copolymer. The recommended dilution is to make a 6 percent solution in water, and apply it at 1/2 gsy (2.26 liters/m^2). The cost of this application is 5.6 cents and 6.26 cents per square yard (6.69 and 7.91 ¢/m^2), F.O.B. Torrence, California and F.O.B. Tucson, Arizona, respectively.
9. Dust Control Oil (37): This is a mixture of petroleum resin and a light hydrocarbon solvent. It is pointed out that this chemical actually did not pass the laboratory test criteria, however, it was included in the field study due to its superior performance observed by the principal investigator in another field study; Sultan (1974d). Two rates of application were used for this chemical. The first application was using 1/4 gsy (1.13 liters/m^2) at a cost of 3.8 cents and 10.9 cents per square yard (4.54 and 13.03 ¢/m^2), F.O.B. Richmond, California and F.O.B. Tucson, Arizona, respectively. The second application was using 1/10 gsy (0.45 liters/m^2) at a cost of 1.52 cents and 4.36 cents per square yard (1.82 and 5.21 ¢/m^2), F.O.B. Richmond, California and F.O.B. Tucson, Arizona, respectively.
10. Dust Stop (38): This is an acrylonitrile butadiene styrene co-polymer. The dilution ratio is 1 to 20 in water, and solution

applied at 1/2 gsy (22.6 liters/m^2). The cost of the application is 2.6 cents and 3.36 cents per square yard (3.11 and 4.02 ¢/m^2), F.O.B. Dover, Delaware and F.O.B. Tucson, Arizona, respectively.

11. Foramine 99-194 (41): This is a urea-formaldehyde resin in water solution. Recommended application was to add 0.18 lb. (81.6 gm) of water to each 1.0 lbs. (453.6 gms) of chemical, and apply the solution at 1.0 lb per square yard (0.54 Kg/m^2). In the field however, additional water had to be added to the same recommended chemical amount in order to be able to spray the solution. The field solution was applied at 1/4 gsy (1.13 liters/m^2) which included 0.82 lb. (0.37 Kg) of the chemical. The cost of this application is 6.8 cents and 10.1 cents per square yard (8.13 and 12.08 ¢/m^2), F.O.B. Tacoma, Washington, and F.O.B. Tucson, Arizona, respectively.

12. Norlig 41 + F-125 (46): This is a mixture of Norlig 41 solution and Formula 125 solution. Norlig 41 is a solution of chemicals and a lignin sulfonate base. Formula 125 is mainly a sodium methyl siliconate with other additives. The recommended application is a mix of (1:4) solution of Norlig 41 in water and (1:40) solution of F-125 in water at the ratio of 4:1, respectively; and applied at 1.0 gsy (4.52 liters/m^2). The cost of this application is 9.1 cents per square yard (10.88 ¢/m^2), F.O.B. Tucson, Arizona.

The chemical solutions were applied in the field using a John Bean mobile sprayer (50 gallons capacity) provided by General Control Company of Tucson, Arizona. It is pointed out that after every application, the sprayer tank and hose were rinsed clean with water, before starting the next chemical solution. Dust Control Oil had to be rinsed with gasoline. The chemicals were applied in the field between May 20-22, 1974

ADOT Yard Site

This site was selected for a second field application after the heavy growth of weeds was encountered at the AES farm site. An isolated area adjacent to the ADOT District Maintenance Yard, west of I-10 and north of Grant Road seemed appropriate for the purpose. The site was cleared of a light grass growth and, to our knowledge, was never used for agricultural purposes before. The site was prepared similar to the AES farm site. A site plan for the new Yard Site is given as Figure 2. Several of the plots were avoided since they were located at a depressed zone and would be flooded during the evaluation period after heavy rainfalls.

This time a weed control agent "Princep-80W" which includes an 80 percent Simazine active ingredient was added to the chemical solution. This chemical agent was recommended and donated by General Control Company of Tucson, Arizona. The recommended rate of application for Princep-80W was set at 10 lbs. per acre. During the application, enough material was mixed in water then added to the chemical water solution. The chemicals, dilutions, rates of application, and method of application used are similar to those discussed and used previously for the AES farm site application. The ADOT Yard site was sprayed on September 28-29, 1974. Properties of the surface soils at this site are given in Table 1.

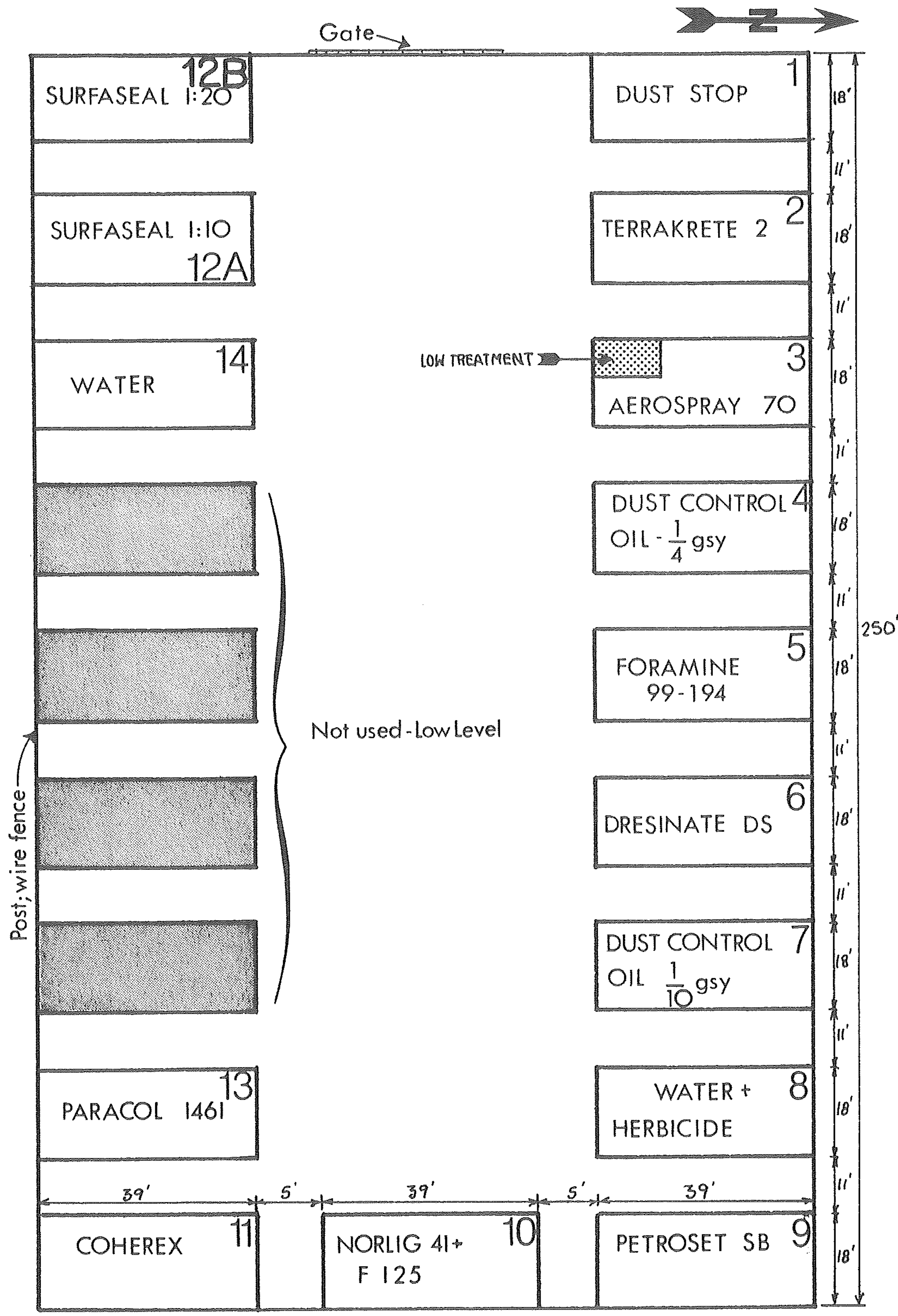


FIGURE 2- SITE PLAN, ADOT YARD-SITE

CHAPTER 3

FIELD MONITORING TESTS - DUST CONTROL SITES

The field evaluation techniques used for monitoring and evaluating the performance of the chemical applications on the dust control sites were similar to those developed and reported previously by the principal investigator, Sultan (1974d). It is pointed out that the field evaluation and monitoring techniques used in this phase were developed and/or modified by the principal investigator, due to the lack of well defined and widely accepted standardized tests that can be used for such monitoring. The methods of evaluation used are briefly outlined below; and were conducted on a bi-weekly basis whenever the weather permitted.

Sampling of Wind Blown Dust (Hi-Vol)

A small Dayton Pole Blower was used as a wind simulator to stir dust particles off the surface. The blower was placed on an inclined steel support such that the air flow would hit the ground surface at an angle of about 40^{o} with the horizontal. The wind velocity at the mouth of the blower was about 12 mph (19.3 Km/hr) and reduced to approximately 8 mph (12.8 Km/hr) at the point of impact on the ground. A High Volume Air Sampler (Harding and Hendrickson 1964 and Air Sampling Instruments 1966, pp. B-1-22- to B-1-26) was placed at a distance of four feet away from the blower along the direction of wind flow. A glass fiber (Gelman Type A) filter paper 8 in. x 10 in. (20.3 cm x 25.4 cm) in size was used to collect the dust particulates on it (Air Sampling Instruments 1966

p. B-2-4). This instrument and filter paper type are used by Pima County Air Pollution Control Division. The same kind of instrument or very similar to it is being used by most air pollution agencies including the National Air Pollution Control Administration.

Sampling was conducted with the wind blower on and the High Volume Sampler (Hi-Vol) drawing air at a flow rate of about 50 cfm (1.4 m^3/min) over a 5 min. period. Both the blower and the Hi-Vol were operated using a gasoline driven electric generator. A schematic drawing of the test set-up is given in Figure 3. The development and modification of this test and the reasoning behind the chosen parameters are given in Appendix A.

After the 5 min. dust collection, the filter paper was removed from the Hi-Vol and weighed in the laboratory. The difference between its final and original weights indicates the amount of dust collected as measured to the nearest milligram (mg). The amount of dust particulates collected during the 5 min. period was computed in micrograms per cubic meter ($\mu g/m^3$) since this unit is the one used by most agencies as a measure of the concentration of dust particulates in the atmosphere.

In the days when the atmosphere seemed to have a reasonably high dust particulate concentration, one reading of the Hi-Vol for a 5 min. period without the blower operating was taken. All readings taken during the corresponding days were corrected by subtracting the atmosphere reading from the actual readings.

In order to evaluate the relative amount of dust fallout from untreated areas on the treated plots, a plywood sheet 4.0 feet (1.22 m) by 6.0 feet (1.83 m) was placed on the ground and left in the field continuously. A Hi-Vol reading was always taken for this plywood sheet in order to take into consideration the amount of accumulated dust other

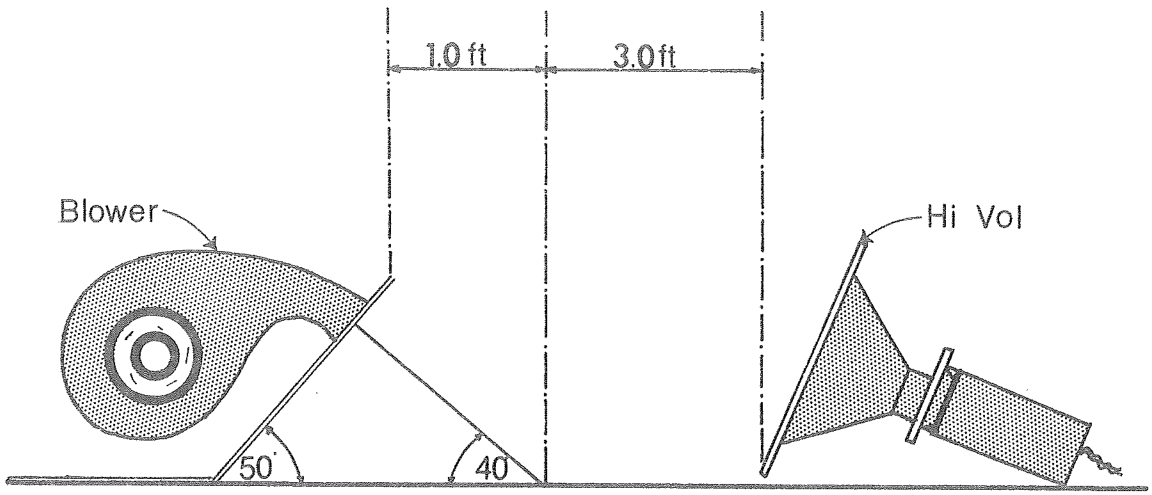


FIGURE 3- SCHEMATIC DIAGRAM OF HI-VOL AND BLOWER ARRAGEMENT

than wind stirred up dust. A field test set-up for the Hi-Vol test is shown in Fiugre 4. Figure 5 shows a close-up of the filter paper in the Hi-Vol unit with the collected dust particulates on its surface.

It is pointed out that the Hi-Vol readings were conducted at various spots on each plot and not at a specific zone. The later method would have underestimated the amounts of dust collection after the first few readings.

Sampling for Extraction Test

Soil samples from the surface of the treated zones were obtained and used in an extraction test to determine the amount of benzene soluble organic matter present. Comparing the extracted amounts obtained from samples taken at different periods after application, a quantitative evaluation of the degree of leaching of the chemical is obtained.

A thin cup. 2-3/4 in. (7.0 cm) in diameter and 5/16 in. (0.8 cm) high, was pushed into the surface soil using a rubber mallet until its top was flush with the ground surface. The surface soil around the perimeter of the cup was then removed with a narrow spatula. A 3 in. (7.62 cm) wide spatula was then pushed underneath the cup to support the soil within it. The cup, with the soil in it, was then raised from the gound with the spatula, and turned over while the soil was still confined by the spatula. The soil surface in the cup was trimmed flush with the edges of the cup, and the soil was then saved in a tin can. A photograph illustrating the retrieving of a specimen in the field is shown in Figure 6. For each plot, a specific zone where the chemical spray-on application appeared to be quite uniform, was selected to collect the extraction specimens from. This practice was intended to reduce the variability of the amount

FIGURE 4. Hi-Vol Test Set-up for Dust Collection

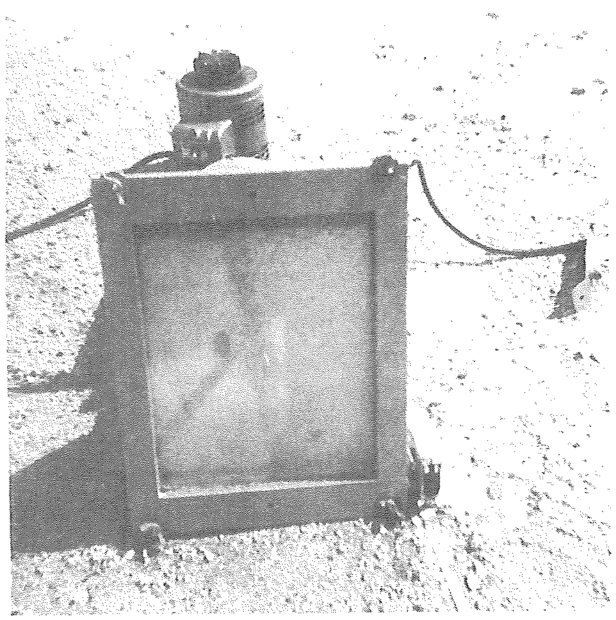


FIGURE 5. Hi-Vol Filter Paper Showing Collected Dust

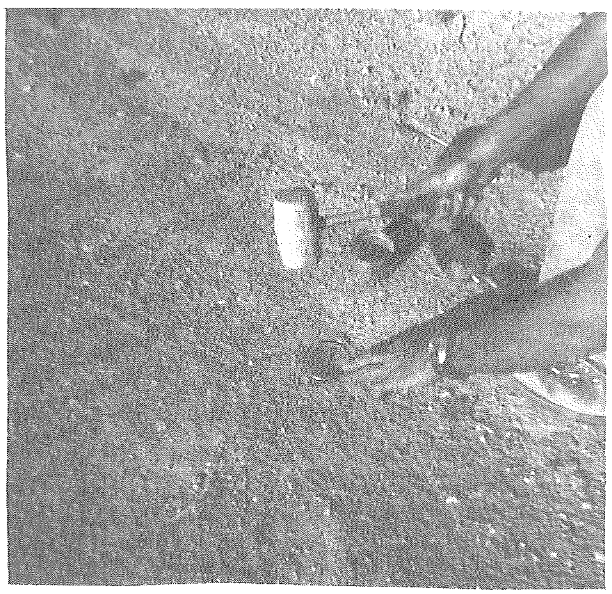


FIGURE 6. Removal of Extraction Specimen

of chemical in the treated soil that may occur due to changes in spray-on rate of application.

It is pointed out that after testing the first set of specimens it appeared that the benzene-extracted materials for most of the chemicals were not in the anticipated order of magnitude, Sultan (1974d). Accordingly, extraction tests using benzene and water as the extracting fluids were run on laboratory-made control specimens. The results of these tests indicated further that the extracted material for most chemicals are still low, except that the water extracted material from the Norlig 41 and F-125 was significantly higher than that extracted by benzene.

Since this test essentially evaluates the degree of leaching out of each chemical individually with time, it was decided to continue the benzene as the extracting fluid, except in the case of the chemical composed of the Norlig 41 and F-125 mixture where water was used instead.

In the laboratory the benzene extraction test was conducted on specimens (run in duplicates) obtained from each application zone. The weight of the extracted organics was measured to the nearest milligram (mg), and converted (according to the area of the cup) into grams per square meter (gm/m^2).

The extraction procedure is outlined in Appendix B and is very similar to that outlined in the Public Health Service Publication No. 978, 1962 (p. 213) and the same as given by Sultan (1974d).

Visual Inspection and Evaluation

In addition to the quantitative evaluation techniques discussed above, a qualitative evaluation was made periodically on the condition of each test plot. This evaluation includes condition of the surface, thickness and firmness of crust, color change, cracks and vegetation growth. This inspection supplemented the other tests and gave a handle in spotting erratic or unexpected results.

CHAPTER 4

FIELD TESTING DATA AND RESULTS - DUST CONTROL SITES

In this chapter the collected field testing data at the dust control sites are presented and discussed. Data collected at the two sites, for each evaluation method, are presented together, analysed, and a comparative evaluation for the chemical treatments is given.

Hi-Vol Dust Collection Data

AES Farm Site

Hi-Vol dust collection tests were conducted at this site at approximately 2-week intervals between June 3, 1974 and July 28, 1975. However, by August 1974 the heavy vegetation (weed) growth encountered at the site made it difficult to rely on the collected dust specimens. The presence of this excessive weed growth appeared to interfer with the wind generated by the blower and thus affected the collected dust particulates. Figures 7 and 8 show the vegetation growth encountered at the Paracol 1461 site and the Terrakrete #2 site, respectively. These photographs were taken on August 10, 1974.

The collected Hi-Vol dust particulates in $\mu g/m^3$ at the AES Farm site are given in Table 2. The accumulated rainfall at the site since the chemicals were applied is given, along with the degree of wetness of the surface soils as observed at the time of the test.

When the collected data were analysed, it was apparent that the dust collected values became increasingly erratic in nature due to the

FIGURE 7 Vegetation Growth at Paracol 1461 Plot

FIGURE 8 Vegetation Growth at Terrakrete #2 Plot

TABLE 2

COLLECTED HI-VOL DUST PARTICULATES ($\mu g/m^3$)

AES FARM SITE

Chemical / Date / Accum. Rain	6/3/74 0.0"(D)	6/17/74 0.01"(D)	7/6/74 0.17"(D)	7/23/74 1.54"(D)	8/6/74 3.71"(M)
Water (Control	64301	58587	58468	3963	2416
Dust Stop	458	7206	1807	1501	2931
Terrakrete #2	182	614	920	1062	1177
Aerospray 70	846	2025	4439	1076	1011
Dust Control Oil 1/10 gsy	202	509	1708	736	3512
Foramine 99-194	890	2712	4921	2761	3956
Dresinate DS-60W-80F	312	1441	3048	761	1114
Dust Control Oil 1/4 gsy	164	344	1119	747	892
Petroset SB	834	2365	3391	736	1827
Norlig 41 + F-125	467	685	2491	611	823
Coherex	875	1841	4857	1073	935
Surfaseal 1:10	220	475	1034	609	1464
Surfaseal 1:20	639	1473	2792	425	1501
Paracol 1461	989	2464	5152	609	1453

(D) = Dry (M) = Moist (W) = Wet

TABLE 2 (Concluded)

Date Accum. Rain Chemical	8/21/74 3.71"(D)	9/25/74 6.75"(W)	Remarks
Water (Control)	54616	537	Erratic data were collected between 10/17/74 and 7/28/75 due to excessive ween and brush growth. These data were discarded.
Dust Stop	5862	382	
Terrakrete #2	2478	68	
Aerospray 70	8751	156	
Dust Control Oil 1/10 gsy	5094	99	
Foramine 99-194	8921	523	
Dresinate DS-60W-80F	7422	254	
Dust Control Oil 1/4 gsy	3441	339	
Petroset SB	8312	636	
Norlig 41 + F-125	4490	297	
Coherex	2903	368	
Surfaseal 1:10	2972	56	
Surfaseal 1:20	6397	580	
Paracol 1461	8949	269	

(D) = Dry (W) = Wet

TABLE 3

PERFORMANCE RATINGS AND PLOT CONDITIONS, AES FARM SITE

Rating	Chemical	Percent* Control	Description of Plot Condition 9/25/74
1	Terrakrete #2	96.1	Natural color, heavy vegetation, hard crust 1/4', light cracks
2	Surfaseal 1:10	95.4	Brown, light vegetation, v.hard crust 1/4', some cracks
3	Dust Control Oil, 1/4 gsy	94.6	Black, light vegetation, soft crust 5/16', light cracks
4	Norlig 41 + F-125	93.0	Lt. brown, light vegetation, hard crust 3/16', some cracks
5	Coherex	92.4	Natural, v. light vegetation, med. crust 3/16',some cracks
6	Dust Control Oil, 1/10 gsy	92.1	Grey-brn., med. vegetation, med.crust 3/16', some cracks
7	Surfaseal 1:20	90.0	Lt. brown, lt. vegetation, hard crust 3/16',some cracks
8	Dust Stop	88.8	Natural, med. vegetation, hard crust 3/10', some cracks
9	Dresinate DS-60W-80F	88.4	Natural, lt. vegetation, hard crust 3/16', cracks
10	Petroset SB	87.1	Natural, v. heavy vegetation, hard crust 3/16', some cracks
11	Aerospray 70	86.4	Lt. brown, v. lt. vegetation, hard crust 3/16', some cracks
12	Foramine 99-194	86.1	Natural, v. lt. vegetation, v. weak crust 1/16'', many cracks
13	Paracol 1461	86.0	Natural, v. heavy vegetation, hard crust 3/16', cracks

excessive vegetation growth. Accordingly, all dust collection data at this site beyond September 1974 were considered to be not representative of the surface condition and were thus discarded.

The results given in Table 2 indicate the following:

1. During the reported monitoring period of 4 months, and actually during the entire field testing period of 14 months, the applied chemical stabilizers afforded good means for controlling dust due to wind. The degree of control varied slightly among the applied chemicals during the initial 4-month period.
2. The degree of wetness of the treated and untreated surfaces (whether dry, moist, or wet) had a profound effect on the amount of dust stirred-up by the wind. As would be expected the higher the moisture content in the surface soil, the lower were the amounts of dust collected.
3. In general the amount of dust collected at each treated plot increased with time but at variable rates.
4. Based on the results reported for the initial 4-month period, the applied chemicals were rated according to their degree of dust control as compared with the control plot (sprayed with water). This rating for the chemicals, in order of decreasing performance, is given in Table 3 along with the degree of dust control afforded by the treatment at the end of the reported 4-month period. Also given in Table 3 is the general condition of each treated plot including surface condition, color, crust, cracks and vegetation growth.

ADOT Yard Site

Hi-Vol dust collection tests were conducted at this site at approximately 2-week intervals between October 17, 1974 and September 29, 1975. The collected Hi-Vol dust particulates in $\mu g/m^3$ at the ADOT Yard site are given in Table 4. The accumulated rainfall at the site since the chemicals were applied is given, along with the degree of wetness of the surface soils as observed at the time of the test.

The results of the tests given in Table 4 indicate the following:

1. The addition of the weed control agent "Princep-80W" inhibited vegetation growth at all the chemically treated plots.
2. The addition of this weed control agent had virtually no effect on controlling dust particulates stirred-up by wind. This is manifested by comparing the dust concentrations obtained from the untreated plot and that sprayed with a solution of the weed control agent in water.
3. During the reported monitoring period of 12-months, the applied chemical stabilizers afforded means for controlling dust stirred-up by wind. The degree of control, however, varied widely among the applied chemicals by the end of this 12-month period.
4. The degree of wetness of the treated and untreated surfaces (whether dry, moist, or wet) had a profound effect on the amount of dust stirred-up by wind. As would be expected the wetter the surface soil, the lower were the amounts of dust collected.
5. In general, the amount of dust collected at each treated plot increased with time, but at variable rates, however.
6. Based on the results obtained during this 12-month monitoring period, the applied chemicals were rated according to their

TABLE 4

COLLECTED HI-VOL DUST PARTICULATES (μg/m^3)
ADOT YARD SITE

Date / Accum. Rain / Chemical	10/17/74 0.86"(D)	11/6/74 2.09"(D)	11/17/74 2.77"(D)	11/30/74 2.77"(D)	12/19/74 2.91"(D)
Water + Herbicide	36580	36728	35505	37530	38413
Untreated	37653	36265	34304	38915	38890
Dust Stop	537	1357	1880	2357	2693
Terrakrete #2	85	184	385	540	477
Aerospray 70	128	253	547	1428	1262
Dust Control Oil 1/4 gsy	113	165	320	742	790
Foramine 99-194	856	1356	2858	8742	10209
Dresinate DS-60W-80F	762	1250	2428	7088	12325
Dust Control Oil 1/10 gsy	369	387	518	855	929
Petroset SB	545	871	1243	3279	3260
Norlig 41 + F-125	364	448	617	975	1109
Coherex	410	847	1364	3678	4530
Surfaseal 1:10	178	218	393	534	497
Surfaseal 1:20	181	323	518	703	862
Paracol 1461	343	460	757	1035	1408

(D) = Dry

TABLE 4 (Continued)

Date Accum. Rain Chemical	1/7/75 3.11"(D)	1/18/75 3.11"(D)	2/1/75 3.64"(W)	2/15/75 3.75"(M)	3/31/75 4.66"(D)
Water + Herbicide	38936	39129	2551	7707	34480
Untreated	37576	39440	2456	6209	34746
Dust Stop	2961	3587	650	1219	2961
Terrakrete #2	608	656	127	232	322
Aerospray 70	1507	1709	163	346	876
Dust Control Oil 1/4 gsy	872	982	152	263	707
Foramine 99-194	11675	20892	2124	5650	9569
Dresinate DS-60W-80F	14710	16848	1742	4781	10997
Dust Control Oil 1/10 gsy	1081	1240	431	941	1104
Petroset SB	4385	6099	1668	3760	7230
Norlig 41 + F-125	1547	1789	547	1187	1923
Coherex	5215	6818	1654	4608	6438
Surfaseal 1:10	792	939	172	345	580
Surfaseal 1:20	1018	1458	368	805	1304
Paracol 1461	1633	1963	483	1016	2244

(D) = Dry (M) = Moist (W) = Wet

TABLE 4 (Continued)

Chemical / Date / Accum. Rain	4/12/75 5.19"(M)	4/26/75 5.26"(D)	5/10/75 5.26"(D)	5/23/75 5.26"(D)	6/6/75 5.26"(D)
Water + Herbicide	6951	35534	36788	37093	38480
Untreated	7516	34304	37597	38177	38732
Dust Stop	1360	3247	8369	8830	9820
Terrakrete #2	159	393	530	686	792
Aerospray 70	550	1329	1986	2226	3018
Dust Control Oil 1/4 gsy	300	839	916	1066	1125
Foramine 99-194	5562	11095	24770	27590	31307
Dresinate DS-60W-80F	4795	9385	13961	18955	22637
Dust Control Oil 1/10 gsy	683	1544	1893	2303	2650
Petroset SB	3166	8901	12958	13537	16081
Norlig 41 + F-125	757	2157	2583	2940	3081
Coherex	4148	6777	9830	11372	14661
Surfaseal 1:10	410	1077	1113	1135	1209
Surfaseal 1:20	865	1392	1662	1829	1888
Paracol 1461	1125	2631	2919	3222	3692

(D) = Dry (M) = Moist

TABLE 4 (Continued)

Date Accum. Rain Chemical	6/20/75 5.26"(D)	7/9/75 6.1"(W)	7/23/75 8.40"(D)	8/25/75 9.01"(D)	9/11/75 9.77"(D)
Water + Herbicide	32619	2635	31723	33264	35912
Untreated	33222	2245	32621	34232	36435
Dust Stop	12335	621	11421	13229	14212
Terrakrete #2	875	289	676	753	821
Aerospray 70	3312	361	1321	2301	1916
Dust Control Oil 1/4 gsy	1313	275	821	975	992
Foramine 99-194	32129	2380	31612	33292	34770
Dresinate DS-60W-80F	25312	2171	22315	21819	24518
Dust Contorl Oil 1/10 gsy	2821	682	2315	2891	3112
Petroset SB	15983	1323	16831	17259	18311
Norlig 41 + F-125	3211	621	3115	3331	3192
Coherex	16312	2001	16735	18223	19892
Surfaseal 1:10	1197	380	1025	1171	1219
Surfaseal 1:20	1927	473	1737	1882	2031
Paracol 1461	3961	735	2831	3820	4212

(D) = Dry (W) = Wet

TABLE 4 (Concluded)

Date / Accum. Rain / Chemical	9/29/75 9.83"(D)
Water + Herbicide	35326
Untreated	37636
Dust Stop	13971
Terrakrete #2	894
Aerospray 70	2620
Dust Control Oil 1/4 gsy	1015
Foramine 99-194	33819
Dresinate DS-60W-80F	23873
Dust Control Oil 1/10 gsy	3260
Petroset SB	19021
Norlig 41 + F-125	3650
Coherex	21015
Surfaseal 1:10	1280
Surfaseal 1:20	2052
Paracol 1461	4620

(D) = Dry

degree of dust control as compared with the untreated control plot. This rating for the chemicals, in order of decreasing performance, is given in Table 5 along with the degree of dust control afforded by the treatment at the end of the 12-month monitoring period. Also given in Table 5 is the general condition of each treated plot including surface condition, color, crust, cracks, and vegetation growth.

Discussion of Test Results

1. The results given in Tables 3 and 5 indicate that the best three performing chemicals in the field for controlling dust due to wind are: Terrakrete #2, Surfaseal (1:10 concentration) and Dust Control Oil at 1/4 gsy. These same chemicals maintained the same rating order at the AES Farm site (after 4 months) and at the ADOT Yard site (after 12 months).
2. Several chemicals registered a significant reduction in their degree of dust control with time. After 12 months of field exposure eight chemical treatments indicated a degree of dust control higher than 85 percent. Five chemical treatments afforded a degree of dust control lower than 65 percent.
3. Even though Dust Control Oil did not prove to be a successful treatment based on the laboratory test results, it proved to be one of the best chemical treatments based on its field performance. This chemical showed similarly good field performance for dust control in a previous study, Sultan (1974d). This fact indicates that the laboratory test results may not be necessarily conclusive in predicting field performance of certain chemical treatments for controlling dust due to wind action.

TABLE 5

PERFORMANCE RATINGS AND PLOT CONDITIONS, ADOT YARD SITE

Rating	Chemical	Percent Control	Description of Plot Condition 9/29/75
1	Terrakrete #2	97.7	Natural color, no weeds, hard crust, no cracks
2	Surfaseal 1:10	96.7	Natural color, no weeds, hard crust, no cracks
3	Dust Control Oil, 1/4 gsy	96.7	Dark brown, no weeds, firm crust, no cracks
4	Surfaseal 1:20	94.8	Natural color, no weeds, firm crust, light cracks
5	Dust Control Oil, 1/10 gsy	91.7	Dark brown, no weeds, soft crust, some cracks
6	Aerospray 70	91.6	Natural color, no weeds, firm crust, light cracks
7	Norlig 41 + F-125	90.7	Light brown, no weeds, med. firm crust, light cracks
8	Paracol 1461	88.3	Natural color, no weeds, firm crust, light cracks
9	Dust Stop	64.0	Natural color, no weeds, brittle crust, some cracks
10	Petroset SB	51.8	Natural color, no weeds, thin friable crust, cracks
11	Coherex	46.7	Tan, no weeds, thin friable crust, cracks
12	Dresinate DS-60W-80F	35.8	Natural color, no weeds, loose surface, cracks
13	Foramine 99-194	11.8	Natural color, no weeds, loose surface, cracks

Extraction Test Data

AES Farm Site

Extraction test specimens were taken at this site for a period of 14 months at approximately 2-week intervals between June 3, 1974 and July 28, 1975. The presence of the high vegetation growth at the farm site did not materially affect the specimens, except for exercising additional care in removing these specimens on-site.

The test results obtained from the extraction specimens at the farm site presented as the extraction residue amounts in gm/m^2, are given in Table 6. The accumulated rainfall at the site since the chemicals were applied is also given. The results given in Table 6 indicate the following:

1. There exists a wide range of "organic" extraction residues among the chemical treatments used in the study. Initial residue of 588 gm/m^2 is reported for Dust Control Oil (1/4 gsy); compared with about 17 gm/m^2 for Dust Stop.
2. Based on the field performance of the various treatments and as manifested by the Hi-Vol test results presented previously, it appears that the numerical level of the extracted residue is not directly related to the degree of dust control afforded by the chemical. For example, Terrakrete #2 which was rated best (97.7% control) for dust control as shown in Tables 3 and 5 had its highest extracted residue as 42.5 gm/m^2, while Dust Control Oil-1/4 gsy which was rated third (96.7% control) had its highest extracted residue as 588 gm/m^2.
3. The observation mentioned above points out the possibility that the elements (organic or otherwise) responsible for the soil

TABLE 6

EXTRACTION TEST RESIDUE (gm/m^2)
AES FARM SITE

Date Accum. Rain / Chemical	6/3/74 0.00 in.	6/17/74 0.01 in.	7/6/74 0.17 in.	7/23/74 1.54 in.	8/6/74 3.71 in.
Water (Control)	5.9	5.8	5.6	5.7	5.4
Dust Stop	16.9	16.8	16.2	14.8	13.4
Terrakrete #2	42.5	42.4	41.8	40.4	39.6
Aerospray 70	48.7	48.9	48.2	46.4	43.5
Dust Control Oil 1/10 gsy	238.5	245.0	241.6	236.5	232.2
Foramine 99-194	30.3	30.5	29.5	27.8	25.7
Dresinate DS-60W-80F	60.2	60.1	59.8	57.2	55.4
Dust Control Oil 1/4 gsy	587.6	588.0	574.2	564.3	553.1
Petroset SB	71.9	70.8	70.7	68.4	67.1
Norlig 41 + F-125	157.6	155.1	156.0	150.6	146.2
Coherex	175.6	174.1	172.4	166.5	161.5
Surfaseal 1:10	53.8	53.1	52.6	51.4	49.8
Surfaseal 1:20	30.8	31.3	30.4	29.1	27.9
Paracol 1461	59.6	58.8	58.0	56.2	55.6

TABLE 6 (Continued)

Date Accum. Rain Chemical	8/21/74 3.71 in	9/7/74 5.67 in.	9/21/74 6.43 in.	10/12/74 7.67 in.	11/2/74 8.90 in.
Water (Control)	5.5	4.9	5.1	4.8	5.2
Dust Stop	13.4	12.5	11.4	10.8	10.7
Terrakrete #2	39.5	37.9	37.4	36.8	36.0
Aerospray 70	43.7	42.6	41.8	40.9	40.8
Dust Control Oil 1/10 gsy	230.3	226.6	224.2	219.8	219.6
Foramine 99-194	24.8	23.0	22.2	21.6	21.0
Dresinate DS-60W-80F	54.7	52.2	51.4	50.4	48.5
Dust Control Oil 1/4 gsy	557.8	546.3	540.3	534.6	532.6
Petroset SB	66.4	62.9	61.4	60.2	59.6
Norlig 41 + F-125	145.0	141.9	140.3	138.6	136.7
Coherex	159.6	155.2	150.2	144.3	137.7
Surfaseal 1:10	49.2	44.6	43.2	41.4	41.2
Surfaseal 1:20	27.4	26.7	26.1	24.8	23.9
Paracol 1461	55.3	53.9	51.6	51.2	50.4

TABLE 6 (Continued)

Date Accum. Rain Chemical	11/16/74 9.58 in	11/30/74 9.58 in.	12/19/74 9.72 in.	1/7/75 9.92 in.	1/18/75 9.92 in.
Water (Control	4.9	4.8	4.7	4.9	5.0
Dust Stop	9.7	9.2	8.9	8.9	8.3
Terrakrete #2	35.4	35.5	35.1	34.6	34.5
Aerospray 70	40.1	39.6	39.4	39.2	39.0
Dust Control Oil 1/10 gsy	217.7	216.8	215.7	212.5	212.8
Foramine 99-194	20.1	19.7	18.9	17.5	17.3
Dresinate DS-60W-80F	47.8	47.2	45.3	43.6	42.8
Dust Control Oil 1/4 gsy	528.3	526.1	525.9	523.6	523.0
Petroset SB	59.3	58.5	57.3	56.8	56.1
Norlig 41 + F-125	134.3	133.1	132.6	131.2	130.6
Coherex	132.8	135.5	132.8	129.3	128.5
Surfaseal 1:10	40.3	40.4	39.6	38.2	38.5
Surfaseal 1:20	23.5	23.4	22.9	22.5	23.0
Paracol 1461	49.8	49.9	48.8	48.5	48.1

TABLE 6 (Continued)

Date Accum. Rain Chemical	2/1/75 10.45 in.	2/22/75 10.51 in.	3/15/75 11.35 in.	3/31/75 11.47 in.	4/12/75 12.00 in.
Water (Control)	5.1	5.3	4.9	5.4	5.0
Dust Stop	7.7	7.6	7.4	6.8	6.7
Terrakrete #2	34.1	33.6	32.4	32.4	32.1
Aerospray 70	38.1	38.3	37.6	37.3	36.9
Dust Control Oil 1/10 gsy	210.1	209.7	206.7	204.2	202.8
Foramine 99-194	16.6	16.4	14.8	15.1	14.2
Dresinate DS-60W-80F	39.8	38.0	35.6	34.0	32.7
Dust Control Oil 1/4 gsy	519.9	520.8	514.7	513.9	511.3
Petroset SB	54.5	43.6	42.8	42.7	41.6
Norlig 41 + F-125	128.7	127.6	125.4	125.0	124.5
Coherex	125.2	121.0	117.6	114.2	113.0
Surfaseal 1:10	37.4	37.2	36.4	36.1	35.3
Surfaseal 1:20	22.4	22.1	21.7	21.2	20.7
Paracol 1461	47.3	46.8	43.9	44.3	43.2

TABLE 6 (Continued)

Date / Accum. Rain / Chemical	4/26/75 12.07 in.	5/10/75 12.07 in.	5/23/75 12.07 in.	6/6/75 12.07 in.	6/20/75 12.07 in.
Water (Control)	5.2	5.4	5.2	5.5	5.0
Dust Stop	6.4	6.6	6.3	6.7	6.8
Terrakrete #2	31.5	31.6	31.2	30.8	30.6
Aerospray 70	36.7	36.2	35.8	35.9	35.7
Dust Control Oil 1/10 gsy	200.7	198.5	195.7	193.2	192.1
Foramine 99-194	13.8	13.6	12.8	12.1	11.6
Dresinate DS-60W-80F	31.6	30.2	28.1	27.9	25.7
Dust Control Oil 1/4 gsy	510.0	509.3	506.3	503.4	500.9
Petroset SB	41.2	40.3	39.8	38.5	38.1
Norlig 41 + F-125	123.8	123.5	121.9	120.5	119.4
Coherex	110.5	109.0	108.1	107.3	106.2
Surfaseal 1:10	35.4	34.9	34.7	34.3	34.3
Surfaseal 1:20	20.4	20.5	19.6	19.6	19.2
Paracol 1461	42.6	42.5	42.1	41.5	41.1

TABLE 6 (Concluded)

Chemical / Date / Accum. Rain	7/7/75 12.93 in.	7/28/75 15.21 in.	Percentage Reduction of Extraction Residue
Water (Control	5.2	5.1	-
Dust Stop	6.4	6.6	63
Terrakrete #2	29.3	28.6	33
Aerospray 70	34.8	33.9	31
Dust Control Oil 1/10 gsy	118.2	182.6	25
Foramine 99-194	10.2	9.3	70
Dresinate DS-60W-80F	23.3	19.1	68
Dust Control Oil	496.3	491.8	16
Petroset SB	36.6	33.1	54
Norlig 41 + F-125	117.8	113.1	28
Coherex	101.1	94.3	46
Surfaseal 1:10	33.8	33.1	38
Surfaseal 1:20	18.7	18.3	41
Paracol 1461	40.2	38.2	36

stabilization for dust control may not all be soluble and thus extractable by benzene. However, without the availability of the exact formulations of each chemical (trade secrets), an exact treatment and evaluation of these residues would be almost impossible.

4. In general, however, the amounts of extraction residues obtained for each chemical treatment continued to decrease with time, indicating various rates of leaching out of the soil under effects of rainfall and other environmental conditions.
5. The gradual reduction in the extraction residues with time, appear to be related to the increase in dust collection obtained with the Hi-Vol.
6. The percentage reduction in extractable residues during the 14-month monitoring period ranged between 16% and 70% with an average of about 42% reduction.

ADOT Yard Site

Extraction test specimens were taken at the ADOT Yard site for a period of about 12 months, at approximately 2-week intervals between October 12, 1974 and September 29, 1975. The test results obtained from the extraction specimens at the Yard site, presented as the extraction residue amounts in gm/m^2, are given in Table 7. The accumulated rainfall at the site since the chemicals were applied is also given. The results given in Table 7 are very similar to those given in Table 6 and indicate the following:

1. There exists a wide range of extraction residues among the chemical treatments used in the study. The range varied between about 15 and 600 gm/m^2.

TABLE 7

EXTRACTION TEST RESIDUE (gm/m^2)
ADOT YARD SITE

Chemical / Date / Accum. Rain	10/12/74 0.86 in.	11/2/74 2.09 in.	11/16/74 2.77 in.	11/30/74 2.77 in.	12/19/74 2.91 in.
Water + Herbicide	6.0	5.6	5.2	5.0	4.3
Untreated	4.3	4.7	4.4	4.3	4.2
Dust Stop	14.6	13.2	12.3	12.1	11.8
Terrakrete #2	43.6	41.7	41.0	40.8	39.3
Aerospray 70	52.9	50.7	49.4	49.5	48.4
Dust Control Oil 1/4 gsy	598.7	572.4	565.2	563.0	557.3
Foramine 99-194	34.7	32.8	30.6	30.8	29.8
Dresinate DS-60W-80F	63.9	59.2	56.9	56.3	54.8
Dust Control Oil 1/10 gsy	253.7	246.9	241.5	236.3	230.7
Petroset SB	67.3	62.4	60.4	59.3	58.6
Norlig 41 + F-125	142.8	138.1	132.4	131.6	128.3
Coherex	186.1	174.7	168.4	163.4	160.1
Surfaseal 1:10	52.1	51.3	49.1	49.7	48.3
Surfaseal 1:20	28.5	27.4	26.1	26.3	25.6
Paracol 1461	55.9	54.6	53.4	53.2	52.5

TABLE 7 (Continued)

Chemical \ Date Accum. Rain	1/7/75 3.11 in.	1/18/75 3.11 in.	2/1/75 3.64 in.	2/15/75 3.75 in.	3/15/75 4.54 in.
Water + Herbicide	4.6	4.5	4.7	4.8	4.9
Untreated	4.7	4.2	4.4	4.6	4.5
Dust Stop	11.5	10.4	9.6	9.4	8.9
Terrakrete #2	37.8	39.1	35.2	34.6	33.2
Aerospray 70	48.1	47.3	45.2	44.7	41.3
Dust Control Oil 1/4 gsy	551.2	547.1	541.6	542.6	536.7
Foramine 99-194	28.6	27.0	26.2	23.1	21.8
Dresinate DS-60W-80F	54.2	53.7	51.4	51.7	48.3
Dust Control Oil 1/10 gsy	227.1	225.7	221.2	219.8	210.8
Petroset SB	55.8	56.1	53.5	51.8	47.3
Norlig 41 + F-125	127.7	126.5	123.6	121.8	118.2
Coherex	156.8	155.3	147.2	142.6	138.4
Surfaseal 1:10	46.8	46.1	45.2	44.3	43.1
Surfaseal 1:20	25.2	24.6	23.7	23.2	22.1
Paracol 1461	51.7	51.9	50.3	49.6	49.8

TABLE 7 (Continued)

Chemical / Date / Accum. Rain	3/31/75 4.66 in.	4/12/75 5.19 in.	4/26/75 5.20 in.	5/10/75 5.26 in.	5/23/75 5.26 in.
Water + Herbicide	4.6	4.5	4.0	4.2	4.2
Untreated	4.2	4.5	4.1	4.4	4.6
Dust Stop	8.3	7.5	7.9	7.8	7.7
Terrakrete #2	35.8	33.8	32.1	32.5	31.6
Aerospray 70	41.6	40.9	41.1	38.8	37.9
Dust Control Oil 1/4 gsy	535.2	531.7	528.9	526.6	522.1
Foramine 99-194	20.2	18.9	18.1	17.4	16.2
Dresinate DS-60W-80F	47.2	45.3	43.9	39.6	35.7
Dust Control Oil 1/10 gsy	205.3	199.1	200.7	195.8	193.0
Petroset SB	46.1	43.4	43.9	41.8	40.8
Norlig 41 + F-125	117.3	115.5	114.9	114.7	115.2
Coherex	136.6	128.1	130.8	122.6	118.7
Surfaseal 1:10	42.5	41.3	41.6	40.8	40.6
Surfaseal 1:20	21.5	21.5	21.2	20.8	20.7
Paracol 1461	48.1	47.2	47.2	46.8	46.1

TABLE 7 (continued)

Date Accum. Rain Chemical	6/6/75 5.26 in.	6/20/75 5.26 in.	7/9/75 6.1 in.	7/28/75 8.38 in.	8/11/75 8.75 in.
Water + Herbicide	4.1	4.6	4.3	4.9	4.4
Untreated	4.5	4.4	4.0	4.3	4.6
Dust Stop	6.4	6.8	6.2	5.8	5.9
Terrakrete #2	30.5	29.8	29.1	28.7	26.1
Aerospray 70	36.4	36.2	35.3	34.1	33.8
Dust Control Oil 1/4 gsy	519.9	522.6	518.2	508.1	501.5
Foramine 99-194	15.8	15.2	13.8	12.1	11.5
Dresinate DS-60W-80F	32.1	30.9	28.1	25.2	23.8
Dust Control Oil 1/10 gsy	191.8	190.3	182.9	178.1	175.2
Petroset SB	40.6	39.6	38.9	37.2	36.2
Norlig 41 + F-125	113.6	113.8	110.2	106.1	105.4
Coherex	115.2	110.7	101.3	93.1	87.2
Surfaseal 1:10	40.2	38.9	38.2	36.7	35.6
Surfaseal 1:20	20.2	19.7	19.1	18.7	18.2
Paracol 1461	45.2	44.6	43.8	42.4	41.9

TABLE 7 (Concluded)

Date Accum. Rain Chemical	8/25/75 9.01 in.	9/11/75 9.77 in.	9/29/75 9.83 in.	Percentage Reduction of Extraction Residue
Water + Herbicide	4.6	4.8	4.4	-
Untreated	4.3	4.2	4.1	-
Dust Stop	5.7	5.7	5.5	62
Terrakrete #2	27.5	25.8	26.3	41
Aerospray 70	33.7	31.8	30.7	42
Dust Control Oil 1/4 gsy	496.1	488.8	485.1	20
Foramine 99-194	10.2	9.8	8.8	75
Dresinate DS-60W-80F	21.3	19.2	16.1	75
Dust Control Oil 1/10 gsy	171.6	167.2	162.8	36
Petroset SB	35.6	35.0	34.7	48
Norlig 41 + F-125	140.1	102.8	102.2	28
Coherex	81.2	78.2	73.1	61
Surfaseal 1:10	35.1	34.8	35.2	33
Surfaseal 1:20	17.9	17.6	17.1	40
Paracol 1461	41.3	40.7	40.6	27

2. The addition of the weed control agent did not significantly increase the extraction residue. The maximum measured change was about 1.7 gm/m^2 for the water-sprayed plot.
3. The amount of extracted residues is not directly related to the degree of dust control afforded by the chemical.
4. In general, the amount of extracted residues continued to decrease with time. This reduction ranged between 20% and 75% with an average of about 45%.

Discussion of Test Results

1. The results given in Tables 6 and 7 are quite similar and indicate agreement between the data collected at the two separate sites.
2. The addition of "Princep-80W" as a weed control agent had no effect on the results obtained, other than preventing vegetation growth.
3. Since the numerical amount of the extracted residues for the best performing chemicals showed such a wide variation, it is possible that the elements (organic or otherwise) that are responsible for the soil stabilization may not all be soluble in benzene.
4. A comparison of the degree of dust control, based on the Hi-Vol test, and the percent reduction (leaching) of the extracted residues for the ADOT Yard site is given in Table 8. No direct correlation is apparent between the two criteria, except that the five chemicals exhibiting the lowest degree of control also suffered the largest percent-reductions in the extracted residues.

TABLE 8

COMPARISON OF HI-VOL AND EXTRACTION TEST RESULTS, ADOT YARD SITE

Hi-Vol Rating	Chemical	Hi-Vol Control %	Residue Reduction %
1	Terrakrete #2	97.7	41
2	Surfaseal 1:10	96.7	33
3	Dust Control Oil, 1/4 gsy	96.7	20
4	Surfaseal 1:20	94.8	40
5	Dust Control Oil, 1/10 gsy	91.7	36
6	Aerospray 70	91.6	42
7	Norlig 41 + F-125	90.7	28
8	Paracol 1461	88.3	27
9	Dust Stop	64.0	62
10	Petroset SB	51.8	48
11	Coherex	46.7	61
12	Dresinate DS-60W-80F	35.8	75
13	Foramine 99-194	11.8	75

Visual Inspection and Evaluation

The conditions of the treated surfaces at the two sites were monitored in the field with time. Field observations included color change, firmness of crust, vegetation growth and presence of surface cracks. The results of these field observations, particularly the final conditions of the treated plots, are included in Table 3 and Table 5 for the AES Farm site and the ADOT Yard site, respectively. These results are in general accordance with the quantitative data obtained from the Hi-Vol and the extraction test data.

CHAPTER 5

FIELD APPLICATIONS - ROAD TEST SITE

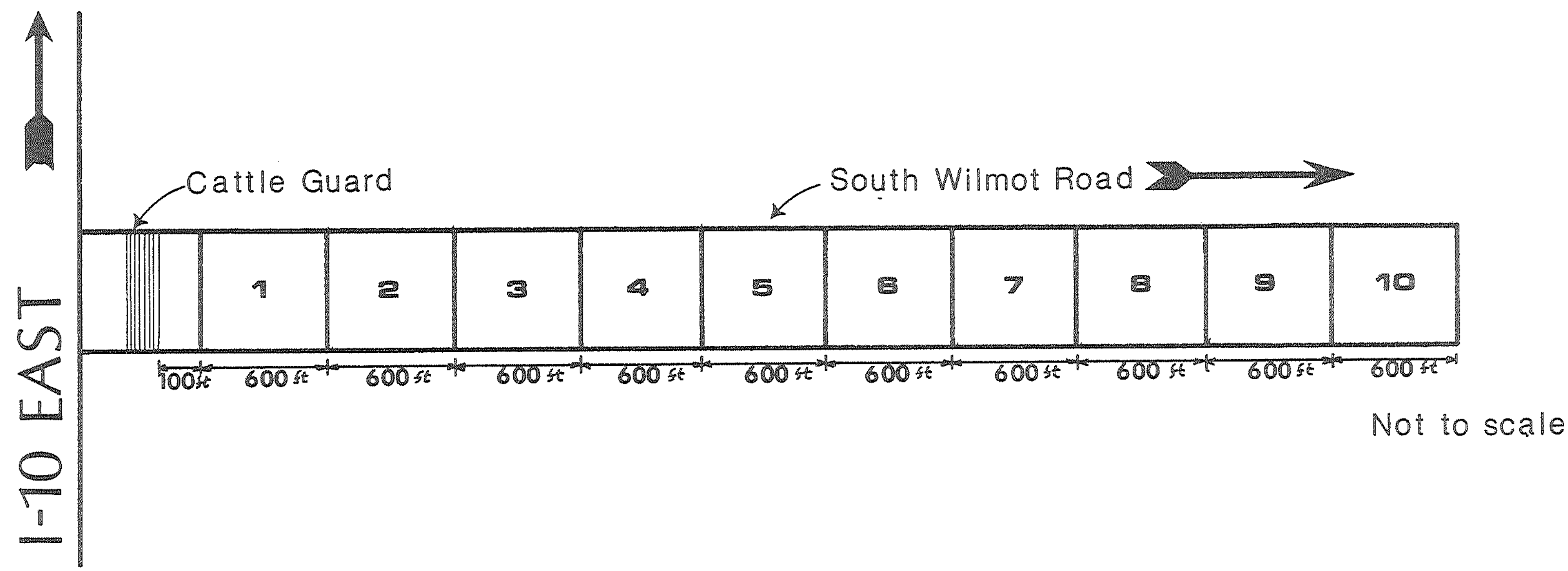
Near the completion of the laboratory testing phase of this project an unpaved road was allocated for our field evaluation by the Pima County Highway Department. The South Wilmot Road (South of I-10) was selected from a few choices given to us. The selection was made due to the reasonable traffic volume (130-150 vpd) on the road and particularly due to the lack of residential housing nearby which reduced the possibility of damage to the field monitoring instruments. The County Engineer also agreed to provide equipment and personnel to work with us for the field application.

The road test site on South Wilmot Road was selected just south of I-10. The first test section starts at approximately 100 feet (30.48 m) south of the cattle guard across the road. Ten sections 600-feet long and 28-feet wide (183 m long and 8.5 m wide) were marked along the road and are referred to as sections no. 1 through 10 going southward, as outlined in Figure 9. Properties of surface soils at the road site are given in Table 1.

Spray-On Applications

Site Preparation

For the spray applications, the surface of the road was usually prepared by surface blading (no ripping) leaving a nominally loosened surface



SPRAY TREATMENT Section

1 DUST CONTROL OIL

2 AEROSPRAY 70

3 WATER (CONTROL)

4 FORAMINE 99-194

5 DUST BOND AND F 125

6 CURASOL-AE

MIXED-IN-DEPHT TREATMENT Section

7 DUST BOND AND F 125

8 REDICOTE-E 52 EMULSION

9 WATER (CONTROL)

10 DUST CONTROL OIL

FIGURE 9- WILMOT ROAD TEST LAYOUT

layer. The chemical solution was prepared in a boot truck and sprayed on the surface through the spray bar. It is pointed out that the boot truck was equipped with a circulating pump that continued to mix the chemicals during application. After spraying, the surface was usually rolled using a rubber tire roller.

Chemicals Applied

As pointed out in the Interim Report, Part II, five chemicals were decided upon for uses in the field application for traffic erosion, using the spray-on application. In addition water treatment was used for one control section. Figure 9 includes the outline of the sections allocated for the chemical treatments. Each one of these chemicals is briefly discussed below. For each chemical the outline includes its major constituents, the dilution ratio, the rate of application and the cost of application per square yard for the chemical only. A brief description of the field application is also given. The number given after the chemical name refers to the number assigned to each chemical during the laboratory testing program.

1. Water (0): Section number 3 was sprayed with 1/2 gsy (2.26 liters/m^2) of water and rolled.
2. Aerospray-70 (7): Its major constituent is a polyvinyl acetate resin. The laboratory dilution ratio is 1 to 10 in water, and the application rate is 1.9 gsy (8.6 liters/m^2). The cost of this chemical application is 43.2 cents and 47.17 cents per square yard (51.66 and 56.41 ¢/m^2), F.O.B. Torrence, California and F.O.B. Tucson, Arizona, respectively.

For the field application, the boot truck was filled with 800 gallons (3 m^3) of water, 270 gallons (1.0 m^3) of chemical were added using a transfer pump, then an additional 800 gallons (3 m^3) of water were added. The solution was then sprayed at 1.0 gsy (4.52 liters/m^2) on the surface of the road using four passes at 1/4 gsy (1.13 liters/m^2) each. This rate of application was decided upon since larger rates caused heavy flooding of the surface. The surface was rolled immediately without noticeable tracking.

This field application is thus a dilution of 1:6 in water, with the solution rate of application at 1.0 gsy (4.52 liters/m^2). The amount of chemical per square yard in the field application is about 84% of that given in the laboratory test. Thus the chemical cost of the actual field application is 36.3 cents and 39.6 cents per square yard (43.4 and 47.4 ¢/m^2), F.O.B. supplier and F.O.B. Tucson, respectively.

3. Curasol AE (9b): This is identified as a polymer dispersion. The laboratory dilution is 1 to 5 in water applied at 1.0 gsy (4.52 liters/m^2). The cost of this chemical application is 43.3 cents and 45.8 cents per square yard (51.8 and 54.8 ¢/m^2), F.O.B. Los Angeles, California and F.O.B. Tucson, Arizona, respectively.

   For the field application, the boot truck was filled with 800 gallons (3 m^3) of water, 270 gallons (1 m^3) of chemical were added using a transfer pump, then an additional 800 gallons (3 m^3) of water were added. The solution was then sprayed at 1.0 gsy (4.52 liters/m^2) on the road surface using four passes at 1/4 gsy (1.13 liters/m^2) each. The surface was rolled immediately without noticeable tracking.

This field application is thus a dilution of 1 to 6 in water instead of 1 to 5 as in the laboratory test. Accordingly, the amount of chemical is about 87% of that given in the laboratory test. The chemical cost of the actual field application is 37.67 cents and 39.84 cents per square yard (45.05 and 47.65 ¢/m^2), F.O.B. supplier and F.O.B. Tucson, respectively.

4. Dust Bond 100 (18b): This is a mixture of lignin sulfonate and other chemicals. The laboratory rate of application is at 1.0 gsy (4.52 liters/m^2) undiluted. This chemical application costs 36 cents per square yard (43.05 ¢/m^2), F.O.B. Tucson and supplier. Since Dust Bond 100 was used to represent the group of lignin sulfonate products as waterproofed with Formula 125, ten gallons of F-125 were also used in the field to achieve the same rate of F-125 application given in chemical No. 46 (Norlig-41 and F-125).

For the field application, the boot truck was filled with about 1,900 gallons (7.1 m^3) of Dust Bond. The chemical was sprayed on the road surface at about 1.0 gsy (4.52 liters/m^2), until there was about 200 gallons (0.75 m^3) left. Two hundred gallons (0.75 m^3) of water were then added along with ten gallons (38 liters) of Formula 125, and the mix was spread evenly on the road surface. The surface was rolled about one hour after spraying, due to high surface moisture, for about half an hour, then left until the following morning since the surface was still quite wet for rolling. The following morning, the rolling continued until sufficient compaction was achieved.

The cost of the field chemical application (Dust Bond 100 + Formula 125) is 41.3 cents per square yard (49.4 ¢/m^2) F.O.B. supplier in Tucson, Arizona.

5. Dust Control Oil (37): This is a mixture of petroleum resin and a light hydrocarbon solvent. The laboratory rate of application is 0.6 gsy (2.71 liters/m^2) undiluted. This chemical application costs 9.0 cents and 25.8 cents per square yard (10.76 and 30.86 ¢/m^2), F.O.B. Richmond, California and F.O.B. Tucson, Arizona, respectively.

   For the field application, the chemical was sprayed on the road surface at 1/2 gsy (2.26 liters/m^2) and rolled immediately without any tracking observed. The cost of this actual field application is 7.5 cents and 21.5 cents per square yard (8.97 and 25.71 ¢/m^2), F.O.B. supplier, and F.O.B. Tucson, Arizona, respectively.

6. Foramine 99-194 (41a): This is a urea-formaldehyde resin in a water solution. Laboratory application calls for 4.1 lbs of the chemical per square yard (2.22 Kg/m^2) with enough water to make a sprayable solution. The cost of this chemical application is 34.0 cents and 50.57 cents per square yard (40.66 and 60.48 ¢/m^2), F.O.B. Tacoma, Washington, and F.O.B. Tucson, Arizona, respectively.

For the field application approximately 720 gallons (2.7 m^3) of the chemical were transferred to the boot truck in addition to about 1,150 gallons (4.3 m^3) of water. The solution was sprayed at 1.0 gsy (4.52 liters/m^2) on the road surface. It is pointed out that the chemical appeared to have hardened somewhat in the drums due to the 103^{0}F (40^{0}C) temperature that lasted three days before the field application. Attempts to roll the surface after application were unsuccessul due to severe tracking. It was about two hours later when the section was rolled with tracking still observed. The road condition after rolling was not very good. The cost of the field application is the same as for the laboratory test, given above.

It is pointed out that after every application the boot truck was rinsed and flushed clean with water before starting the next chemical solution. After application of the Dust Control Oil, the truck was flushed out with gasoline. The chemicals were applied in the field between May 28 and May 31, 1974.

Mixed-in Applications

Four sections of the road (7 through 10) were used for the mixing application of chemicals. Three chemicals and water (control) were used.

Site Preparation

The road surface was given a light water spray and then the surface was ripped, using the ripper attached to the grader, to a depth of about three inches (7.62 cm). It was decided to aim for a three-inch (7.62 cm) stabilized, mixed and compacted mat due to the unavailability of a Seaman mixer and based on previous field results reported by Hoover (1971). In a previous study Hoover (1971) reported difficulties in mixing and compacting a ripped four-inch (10.16 cm) thick layer and recommended future use of three-inch (7.62 cm) thickness. After the road surface was ripped up, additional water was sprayed to reduce surface tension effects, then a portion of the required chemical application was sprayed on the surface. The loosened surface soil was then bladed to the sides of the roads forming two windrows. Each windrow was then spread back on the road surface, sprayed with more chemical and water if necessary and then bladed to form a windrow in the middle of the road. When all the required chemical and enough water (to reach optimum moisture in the field) were added a continuous operation of surface mixing by the blade was done. After complete mixing two side windrows were formed. The mixed soil was then spread on the surface and compacted in two lifts, forming a slight crown near the center.

Each of the chemicals used is briefly discussed below. For each chemical the outline includes its major constituents, the dilution ratio, rate of application, and the cost of application (chemical only) for a three-inch (7.62 cm) mat. The number given after the chemical name refers to the number assigned to each chemical during the laboratory testing program.

1. Water (0): Water spray was given as discussed above, with final moisture content measured at 9.5 percent. Field density reached was about 120 pcf (1.92 gm/cm^3). No tracking during compaction was observed.
2. Redicote E-52 (6): This is a cationic CSS-1h asphalt emulsion.

Laboratory application calls for an 8.4 percent emulsion by dry weight of the soil compacted with enough water to reach optimum moisture content.

For the field application 4500 gallons (16.9 m^3) were used for the three-inch (7.62 cm) compacted mat. At 120 pcf (1.92 gm/cm^3) dry density, this gives 7.44 percent emulsion and 2.41 gsy (10.89 $liters/m^2$) for a three-inch (7.62 cm) mat. The cost of this field application is 53 cents per square yard (63.39 ¢/m^2), F.O.B. supplier in Tucson, Arizona.

3. Dust Bond 100 (18): This is a mixture of lignin sulfonate and other chemicals. The laboratory rate of application is at 1.0 gsy (4.52 $liters/m^2$) undiluted, for a two-inch (5.08 cm) compacted mat. About 2000 gallons (7.5 m^3) of the chemical were sprayed at about 1 gsy (4.52 $liters/m^2$) along with ten gallons (38 liters) of Formula 125, for a compacted three-inch (7.62 cm) mat. This rate of field application costs 41.3 cents per square yard (49.49 ¢/m^2), F.O.B. supplier in Tucson, Arizona.

4. Dust Control Oil (37): This chemical did not pass the laboratory test requirements, but was used as the supplier donated the chemical for field use.

The field application rate was at 1/2 gsy (2.26 $liters/m^2$) undiluted for a three-inch (7.62 cm) compacted mat. The cost of this chemical application is 7.5 cents and 21.5 cents per square yard (8.97 and 22.7 ¢/m^2), F.O.B. Richmond, California and Tucson, Arizona respectively. Two days after the field application, the first 150 feet (30.48 meters) of the treated section (No. 10) was sprayed with a surface application of 1/10 gsy (0.45 liters/m^2) of Dust Control Oil. This first section is identified as section (10a), while the rest of the Dust Control Oil section as (10b).

As with the spray-on application the boot truck was rinsed and flushed clean before starting the next chemical. A separate boot truck was used for the Redicote E-52 emulsion. The chemicals were applied in the field between May 28 and May 31, 1974.